



Effective Use of High-Resolution Models

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Introduction

- Called convection-allowing models, or CAMs, because the model generates deep convection without a convective parameterization - Requires a grid spacing of no more than 4 to 5 km.
- Provide information about features smaller than those resolved by other, coarser resolution models.
- Typically verify better than coarser-resolution models, when subjectively evaluated and when appropriate object-oriented methods are used, though they can perform poorly when measured using traditional "point-by-point" verification methods.
- Can predict convective mode, convective system propagation, diurnal cycle, and other characteristics of convection far better than models run with a convective parameterization.
- Have skill in predicting the mesoscale characteristics/structure of convection, but the prediction of the precise time and location of individual cells or bowing line segments is beyond the capabilities of a CAM. Simulated convective cells are also larger than those that occur in the real atmosphere.
- Initial conditions and lateral boundary conditions must be provided from some other source, typically from coarser-resolution regional or global models.
- Large-scale forcing fed to the CAM through initial and boundary conditions play a dominant role on mesoscale development, and the model forecast solution. Influence of the parent model is even greater when the high-resolution model has a small domain.
- Forecasts are quickly dominated by information passed through the lateral boundary conditions, including spurious artifacts generated by the convective parameterization in the parent model, which can spawn explicit convection deep within the CAM domain.

Considerations

- It is paramount to evaluate the quality of the large-scale forecast provided by the parent model. High-resolution simulations will be as good or bad as the large-scale information supplied through initial and boundary conditions. Unfortunately, much of this data is not easily accessible because of the way high resolution model output is typically shared over the web or through limited capacity communication systems.
- Only run out over a short forecast period due to computational expense and the increasing dominance of the outside boundary condition source over time.
- Future incorporation of high-resolution land surface data, such as soil moisture, into the model will further improve convective initiation.
- Boundary layer mixing parameterizations employed by high-resolution models produce striking forecast differences, such as how quickly boundary layer moisture and/or clouds are dispersed, and how quickly the cap above the PBL and associated convective inhibition erodes, due to different assumptions about mixing at the top of the PBL.

- Forecast biases are affected by parameterizations for boundary layer mixing and microphysics and by numerical schemes used in the dynamics, even more so than for coarser-resolution models.
- If the model uses "cold start" initial conditions interpolated from a coarser-resolution model, it will take a few hours to spin up small-scale features and vertical circulations. Thus, it may be playing catch-up to developments during that time, usually for at least several hours. The best forecast is likely to be in the 6-18 hour time range. This is why the 00Z WRF simulations for the previous day oftentimes outperform the following 12Z run.
- In contrast, using a "hot start" can eliminate spin-up time. A hot start is when the initial conditions incorporate information about vertical circulations on scales the model resolves, such as by assimilating radar observations. If the model uses "hot start" initial conditions with recent radar data, this added information is quickly lost and results in forecast improvement primarily during the first few hours, after which time the larger scale forcing dominates and the forecast closely resembles a cold-start forecast. An example of a "hot start" CAM is the High Resolution Rapid Refresh (HRRR).

Predictability and Skill

- Important to distinguish between unpredictable details, such as the placement and timing of convective cells, and predictable ones, such as the diurnal cycle over complex terrain under quiescent conditions.
- Skill in predicting flow features and precipitation are, like for all models, best at scales greater than 10 times the grid spacing. Thus, do not expect accurate prediction of local flows on the scale of 20 km from a model with a 4-km grid spacing, although the model will show some response such as general upslope or downslope wind directions.

Output

- Model output parameters that involve gradients or vertical motion will have far larger values than seen in output from coarser-resolution models.
- Basic model output parameters will be dominated by mesoscale structure, which can sometimes masking the synoptic structure present in the forecast.
- Model soundings around convection will be notably different than from models with a convective parameterization
- Simulated reflectivity peak values differ between models due to different microphysics parameterizations and algorithm differences even for the same intensity of predicted convection; and these values will almost always be underestimated in the model because the observed reflectivity is dominated by the largest drops and hailstones, which are larger than the model can predict.

Predictability and Final Thoughts

- Mesoscale details are more predictable under some types of situations than others, such as when mesoscale details are those parts driven by large-scale forcing and geographic features resolved by the model (terrain, coastlines, soil moisture gradients if good soil moisture information is provided, etc.)

- The least predictable forecast situations are those which: occur under weak large-scale forcing and are not geographically forced, or result from secondary interactions such as convection-outflow boundary interactions or involve physics-sensitive scenarios (especially interactions among different physics parameterizations, such as low stratus deck erosion which depends on PBL mixing, cloudy radiative transfer, and microphysics).
- Instead of interpreting the model forecast literally for all its details, it can be interpreted as a forecast of a particular type of event in some region over some period of time – oftentimes not in the predicted place and time.